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Management of a power system based on renewable energy

Ronay Karoly, Cristian Dragoş Dumitru*

"Petru Maior University, N.Iorga st., Tirgu Mureş, Romania"

Abstract

The paper presents software and hardware developments for power systems based on renewable energy and their management system. The main purpose is to present the advantage of combined technologies, different solutions for control, communication and data monitoring systems, all of this implemented to develop an efficient energy management system based on renewable energy sources. By using implemented and dedicated hardware and software solutions, the evolution of energy production and consumption can be monitored, and controlled. The advantages of these systems are highlighted by the obtained results from performed experimental simulations such as: implemented SCADA power system based on renewable energy sources, study in GIS models and other informational systems for system performance simulation.

Keywords: power system management; renewable energy;SCADA systems; energy; management; informational systems.

Nomenclature

GIS	geographic information system
HMI	human machine interface
MPPT	maximum power point tracker
PV	photovoltaic

* Cristian Dragoş Dumitru. Tel.: +40-0265-233-212.
E-mail address: cristian.dumitru@ing.upm.ro

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RES	renewable energy sources
SCADA	supervisory control and data acquisition

1. Introduction

The development of technologies assures a higher degree of availability for renewable energy sources (RES), which are reconsidered as importance to improve the power supply security by reducing the dependence on fossil fuels to be exploited or imported, to reduce the greenhouse gas emissions, the greenhouse effect and the global warming. To use these sources properly, to transform and to deliver clean energy, a management system has to be developed [1, 11]. To create an efficient management system some general and important data have to be known and understood. These data are to be collected and they provide general or particular information on the system status. The system can be a mechanical one, hydraulic or, in our case an electrical power system.

To build up a management system in this field, no matter if the generating system is based on classical coal plants, natural earth gases or on renewable energy sources all the essential parameters/data have to be gathered, processed, evaluated and stored on local storage system or on web-servers. The online data flow or the continuous monitoring can be used to process in real time different types of parameters such as production index, equipment states, security parameters, etc. Later, from this information, charts, tables and graphs can be built and the entire system process can be overviewed [2].

2. SCADA HMI systems

An application was developed and the control of the software application can be made through the HMI shown in Fig 1. The HMI serves as an operator control and parameter monitoring. The data can be stored in a database which can be accessed through Office Products Applications for further analysis.

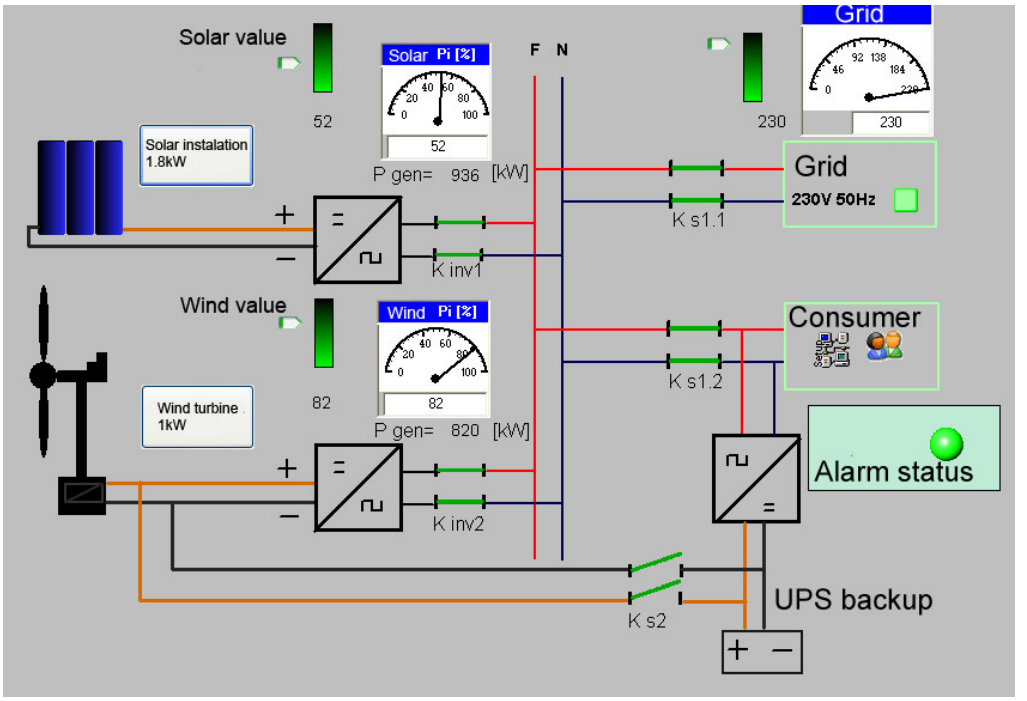

Fig. 1. SCADA HMI for a small consumer (Screen dump).

In Fig. 1, it can be noticed the generated output power from different RES modules and the current state of devices. The two RES have separate power circuits through on-grid inverters and power switches. Although this is an on-grid system with a “safety” mechanism that assures the disconnection from the main grid in the case of grid power losses. The isolation from the grid is provided by a power switch (in this case K s1.1).

The backup system is represented by a battery group and an MPPT charge controller from the wind turbine. The isolation from the grid represents the breakdown function mode notified by an alarm that appears on the screen in such situations. When the system returns to the default function mode, all the tags on the screen indicate that the system has returned to normal. This model is useful for the integration of additional measurements on the power grid into smart micro-grid systems [3, 4, 7].

In the case of larger power consumers it is necessary to adopt a higher voltage level than the one used at the home consumer and so, the system feeding is in a three phase configuration. The configuration can be realized by multiple inverters per phase (as shown in Fig. 2) or by dedicated three phased output inverters (configuration met frequently at PV power plants). The inverters are synchronizing with the grid voltage and frequency. Also, every phase of the inverter is synchronizing independently from each other.

The purpose of the three phase monitor system is to create a balanced feed in system. The output voltage is synchronized to the grid voltage, but the output power depends on the input DC parameters, on the input string voltage and of input current. If the input parameters are different from each other by a given value, the circuit is disconnected from the main low-voltage system by a switch. The main low-voltage switch can be controlled manually or automatically depending on different exploiting conditions. This system is part of a local micro-grid and it has an option to disconnect the micro-grid HV Grid Switch from the main power grid in case of emergency or maintenance. This HMI model can be used as a home energy monitoring system or it can be used as a distinct RES system monitor [4, 6, 8].

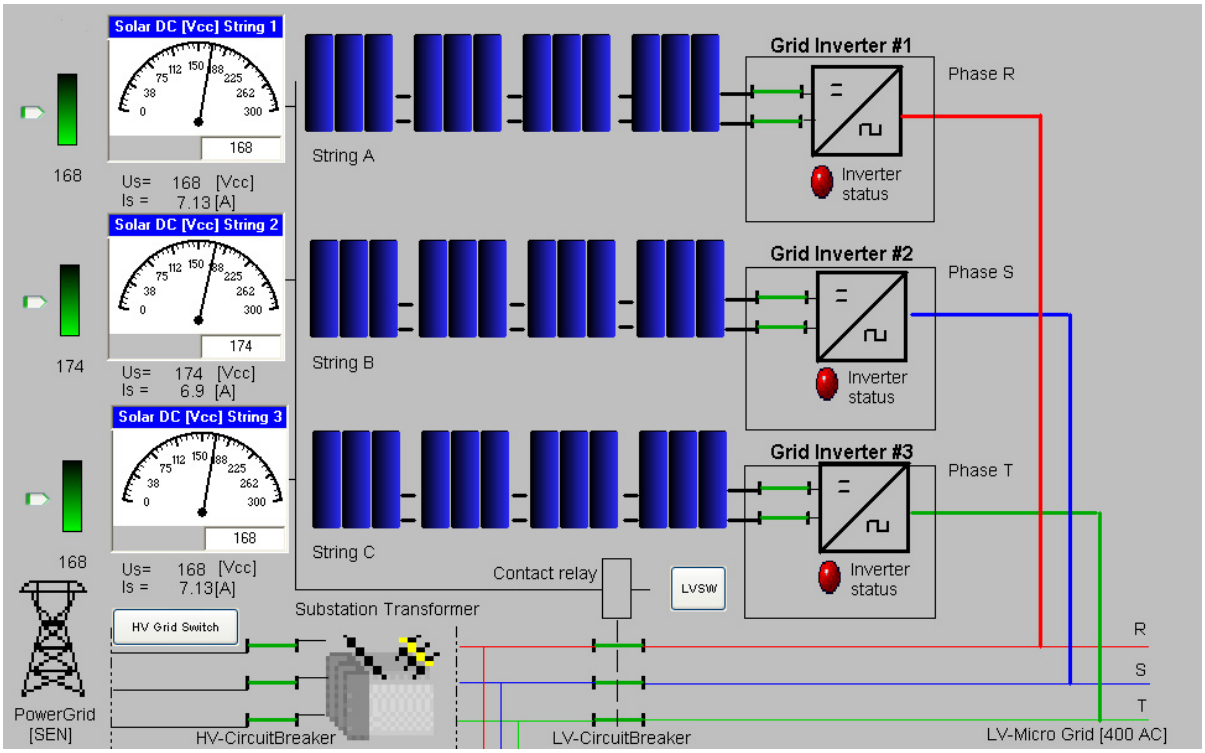

Fig. 2. SCADA HMI for a three phased solar energy system (Screen dump).

3. RES management system

A new level of monitoring and control of RES is represented by the cloud computing integration for existing or for new systems. Cloud computing is a technology based on the Internet that provides remote data centers to manage information services and applications. Cloud computing allows access for individual users and companies to information and applications without installing specific software on their computers (a simple Internet browser is sufficient). Energy metering units and other specific sensors are connected to a microcontroller development board. One of the concepts is to use Arduino development boards, to read in values from the metering units or electrical equipment states and view locally or remotely the different parameters and data. Beside of this the main system functions can be controlled through the microcontroller. By using adaptive shields the development board role in the system can be customized. By the communication shield data through a gateway to other operators or networks can be sent and received. This family of microcontrollers has the advantage of a large appreciation in the engineering community given by the use of these devices in different engineering domains. This hardware solution can be adapted to SCADA software solutions to view the overall system through a graphic user interface. The HMI is built for every specific application.

Fig.3 presents the concept of cloud computing technology integration into an electrical power system based on RES. The integration respects the same principles, both for solar, wind energy systems, hybrid constructions with multiple RES, or for classical power systems. The cloud computing management's main advantage is that the operators and owners can easily connect whit their desktops, laptops or smart-phones, and any other device with a connection to Internet, to view the system technical details on real time. Some brands of equipments give optional monitoring units, but sometimes, multiple equipments have different communication protocols and can't communicate to a central hub. In this case the solution is to use dedicated equipments for the system to communicate with the server machine. The benefits of these systems are the rapidity of information, the low maintenance cost and the independence from other devices or locations and the high reliability [5],[10]. If the clients' number grows, the system can be scaled on demand and can maintain the safety structure. However, there are some risks and in using such systems. The cloud computing systems are dependent on the connection quality and on the services provider. But, with the significant growing of communication infrastructure during last years, these risks are minors.

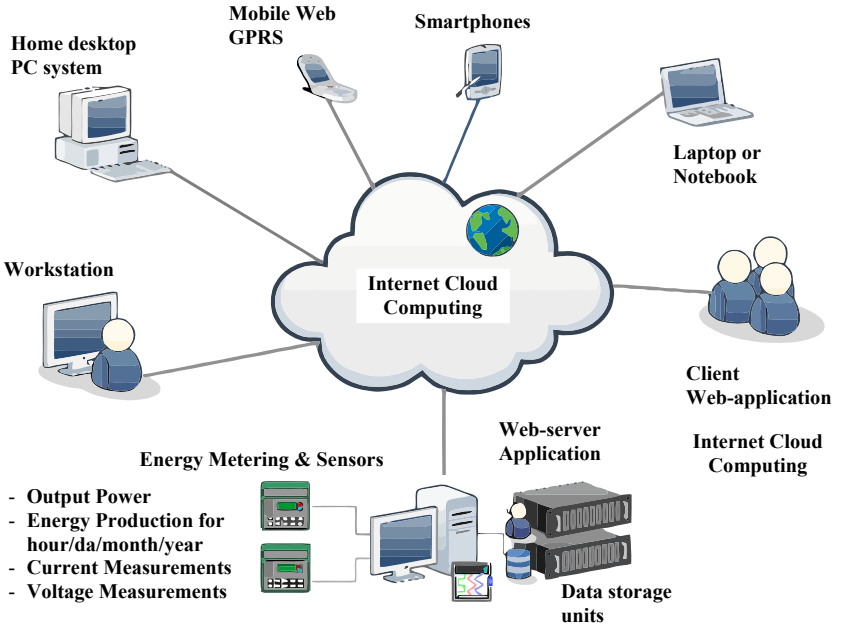

Fig. 3. Cloud computing management integration for RES based power systems

4. Conclusions

With the modern day technology new management levels in the hardware and software domains can be achieved. Adding different measuring technologies and sensors to a system and interfacing it with software applications, robust and complex systems can be obtained. The software applications add a graphical user interface to visualize and to control the options into the hardware units. The system depends on the Wi-Fi connection on a certain levels and in order to use all its listed features, a strong, reliable and secured data communication is needed. The main advantages are better system visualization on the screen and a better management control. The presented system can be developed by modularity. The hardware and the programming stage have a support community and it can be built and modified easily. Later the system can be adapted for electrical equipments.

In conclusion, the paper presents two SCADA HMI systems. For these systems are introduced the concepts of local and remote monitoring by using system microcontrollers as a hardware and networking tools to create a simple and practical management system.

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